

# **The CCPP-ARM Parameterization Testbed (CAPT): Evaluating Climate Models in a Weather Forecasting Framework**

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This work was performed under the auspices of the U. S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48 and was supported by the U. S. Department of Energy Office of Biological and Environmental Research (BER), Climate Research Division. This work also was partially supported at the National Center for Atmospheric Research (NCAR) by the Climate Change Prediction Program (CCPP), which is administered by the USDOE Office of Science, BER program. NCAR is sponsored by the National Science Foundation.

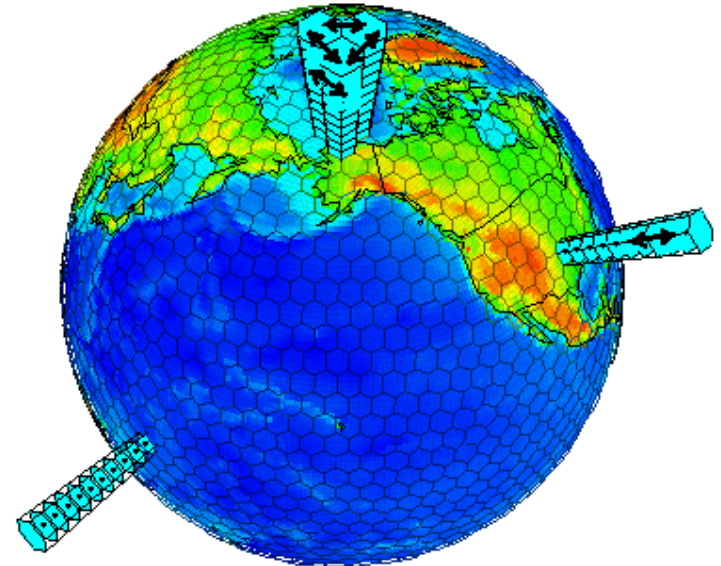
# Outline

- What is CAPT ?
- Description of methodology
- Examples from implementation in NCAR GCM:
  - Identifying moisture prediction problems
  - Improving convective parameterization
- Future plans

# What is CAPT?

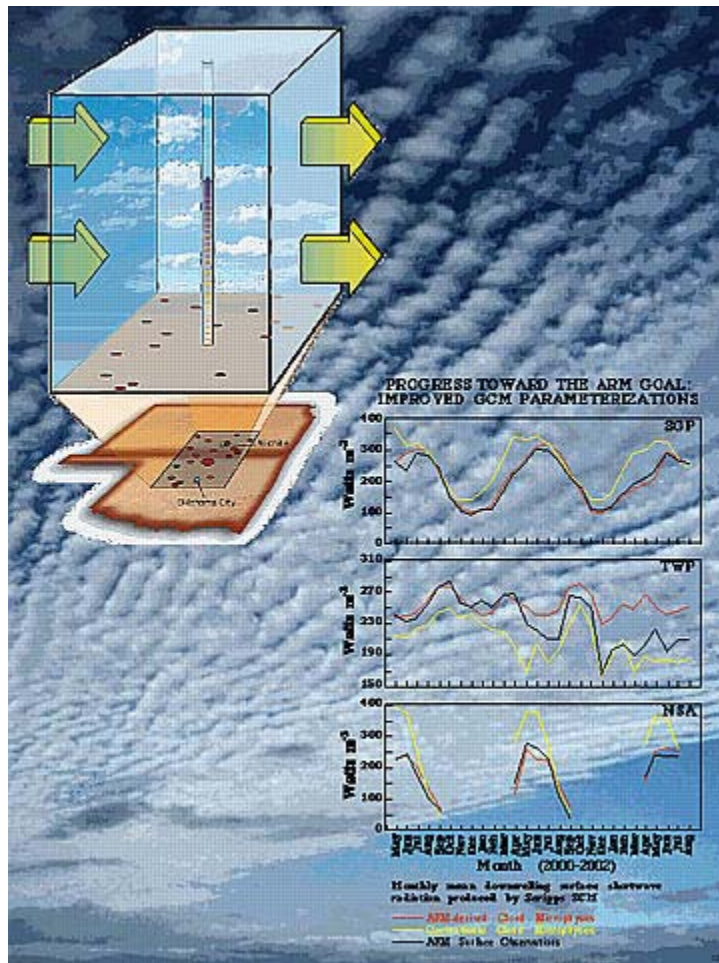
CAPT = CCPP-ARM Parameterization Testbed

- CAPT combines the strengths of 2 Dept. of Energy programs with complementary missions:
  - **CCPP (*Climate Change Prediction Program*)**–  
focus on climate GCM performance
  - **ARM (*Atmospheric Radiation Measurement*)**–  
focus on column observations of radiation & cloud processes and their parameterization in GCMs
- CAPT fosters collaborations between GCM developers (e.g. in CCPP) and parameterization specialists (e.g. in ARM)



Graphic by Dave Randall

ARM observations have been applied to evaluation of climate GCM parameterizations in column models...



ARM observations during Intensive Operational Periods (**IOPs**) have provided dynamical forcings needed to test GCM physics parameterizations in

- Single-Column Models (**SCMs**)
- Cloud-Resolving Models (**CRMs**)

The large-scale dynamical state is close to “truth”, so that it is a realistic environment for driving the model parameterizations.

### Limitations:

- no feedbacks from column to larger scales
- extensive observations needed—cases limited

Another (CAPT) way to evaluate climate GCM parameterizations...

**Initialize the climate GCM from a global NWP analysis, then make short-range (~ 5-day) weather forecasts**

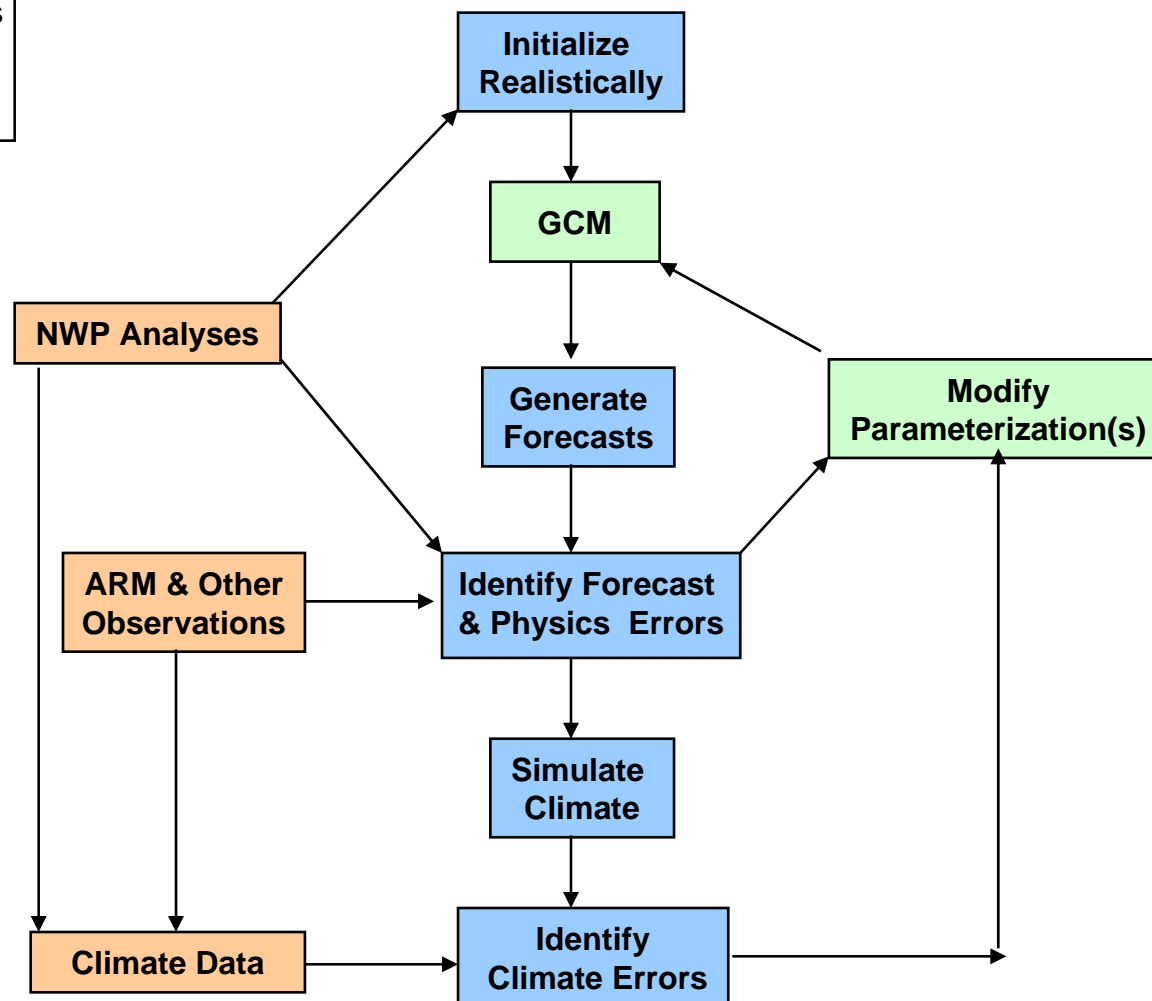
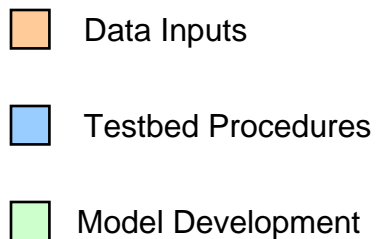
- GCM dynamics start close to “truth”
- GCM systematic errors then are mainly due to physics parameterizations

**Evaluate these model predictions using high-frequency weather analyses & observations of physical processes:**

- GCM evaluation linked to specific processes (i.e. not just statistical comparison)
- More comprehensive parameterization testing than in a column-model setting
  - all feedbacks are included
  - less stringent observational requirements than in column models (since all dynamical forcings are supplied by the GCM )


# CAPT Diagnostic Protocol

## Legend

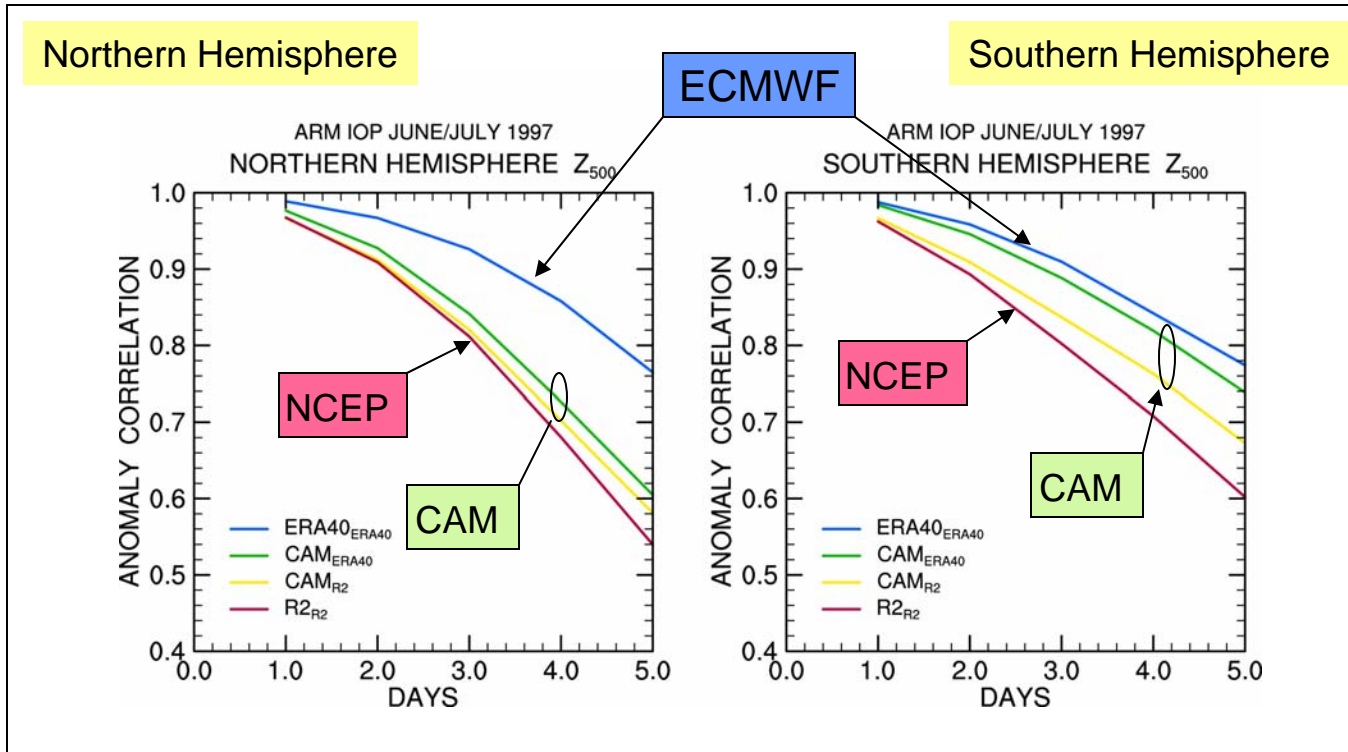


# Implementation for NCAR Community Atmosphere Model (CAM2)

Each day (~ June 18-July 17) of the June/July 1997 IOP at the ARM Southern Great Plains (SGP) site:

1. Initialize CAM2 *globally* using ECMWF ERA40 and NCEP/DOE R2 reanalyses (***mapped to the model's T42 L26 resolution***)
  2. Generate ***5-day forecasts***
  3. Compute the ***mean departure of all the CAM2 forecasts*** from coincident ARM/SGP observations
  4. Diagnose these ***systematic forecast errors***, which are indicative of CAM2 parameterization deficiencies
  5. Change a parameterization → ***test impact by repeating Steps 1 - 4***
  6. Evaluate impact of parameterization change on CAM2 large-scale climate simulation.
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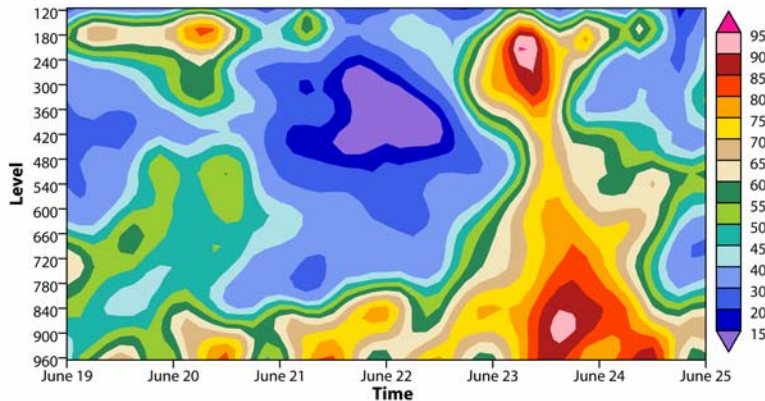
Hemispheric-average 500mb height  
anomaly correlations in June/July 1997



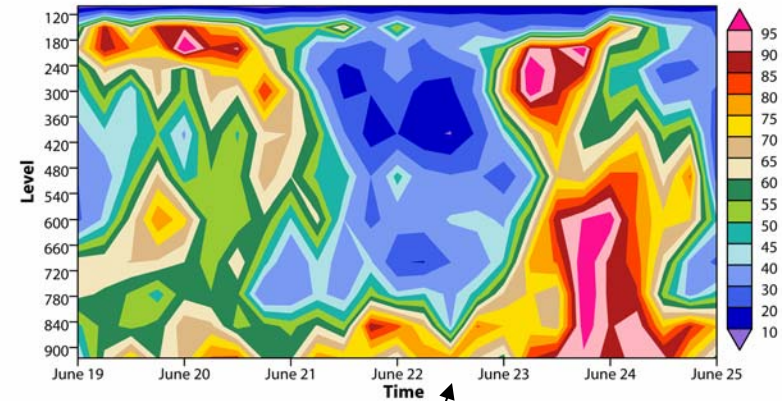
CAM2 500 mb dynamical forecast skill is “competitive”  
with that of the ECMWF and NCEP reanalysis models

## Atmospheric relative humidity at the ARM/SGP site:

ARM / SGP measurements

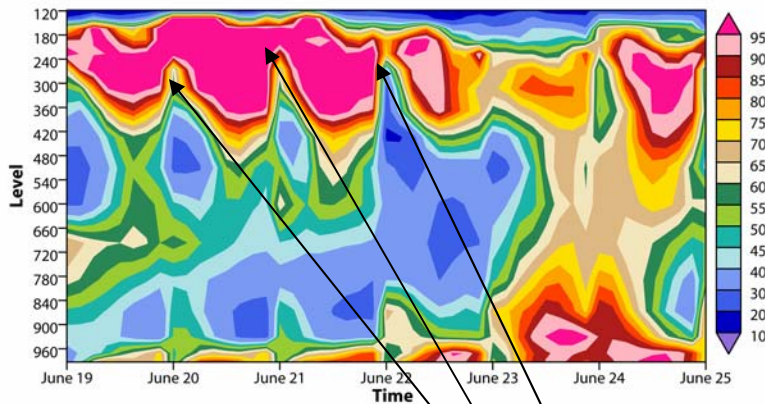


Interpolated ECMWF reanalysis



CAM2 forecasts, valid for 0-24 hours

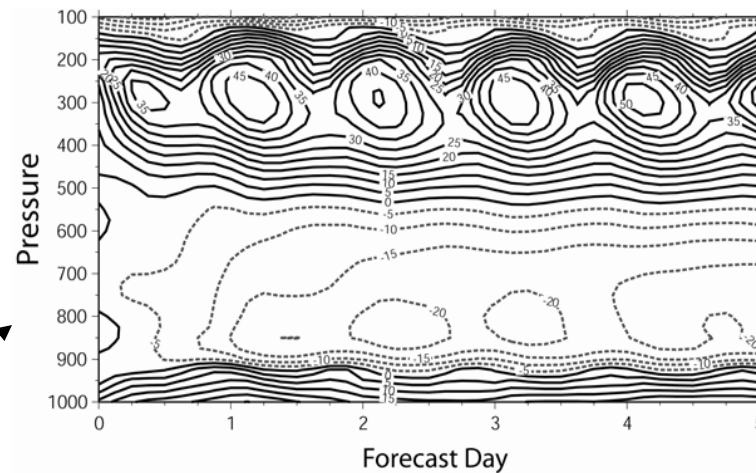
19-24 June, 1997



CAM2 forecasts of relative humidity don't compare so favorably with observations at the ARM / SGP site.

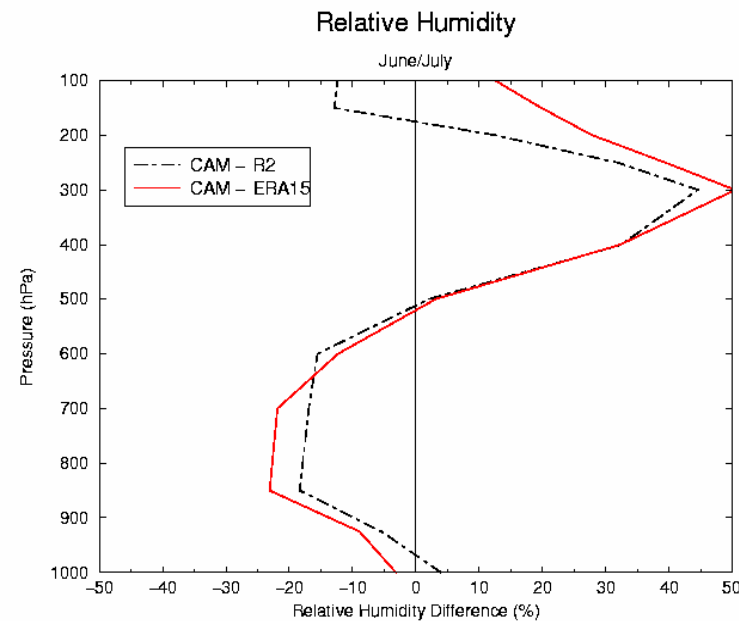
Model re-initialized daily

At the ARM/SGP site, a similar error structure is seen in the CAM2's mean 5-day forecasts of atmospheric relative humidity for June/July 1997, as well as in a 10-year June/July climatology:



Mean June/July 1997  
CAM2 forecast errors  
relative to ARM obs

ARM/SGP Site

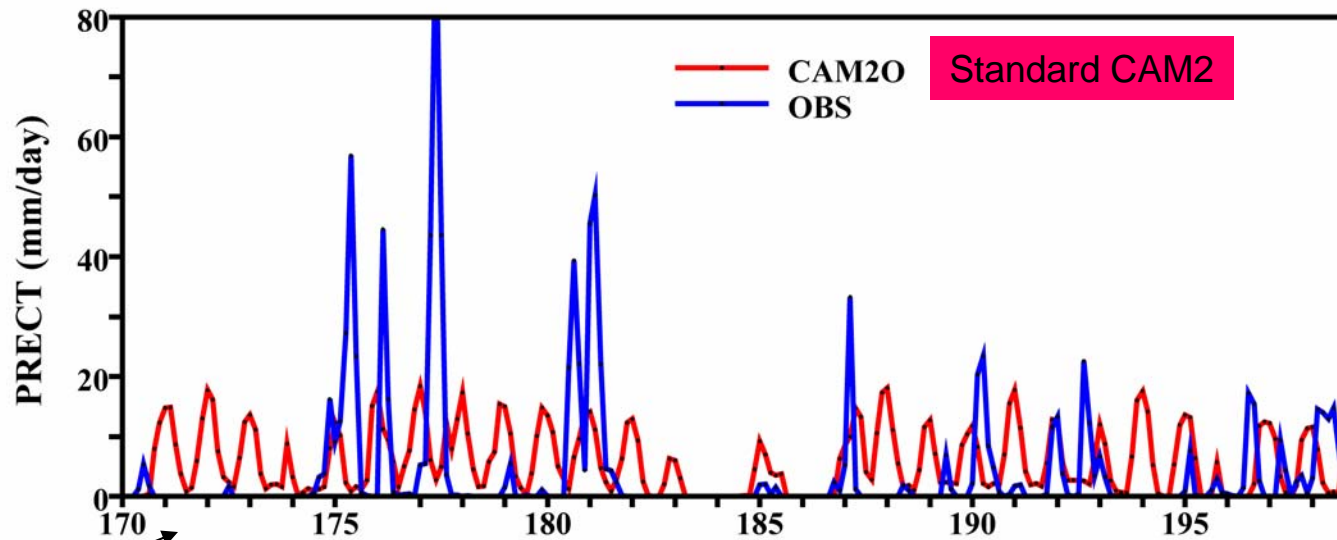


10-year June/July  
CAM2 climatology  
errors relative to  
interpolated reanalyses

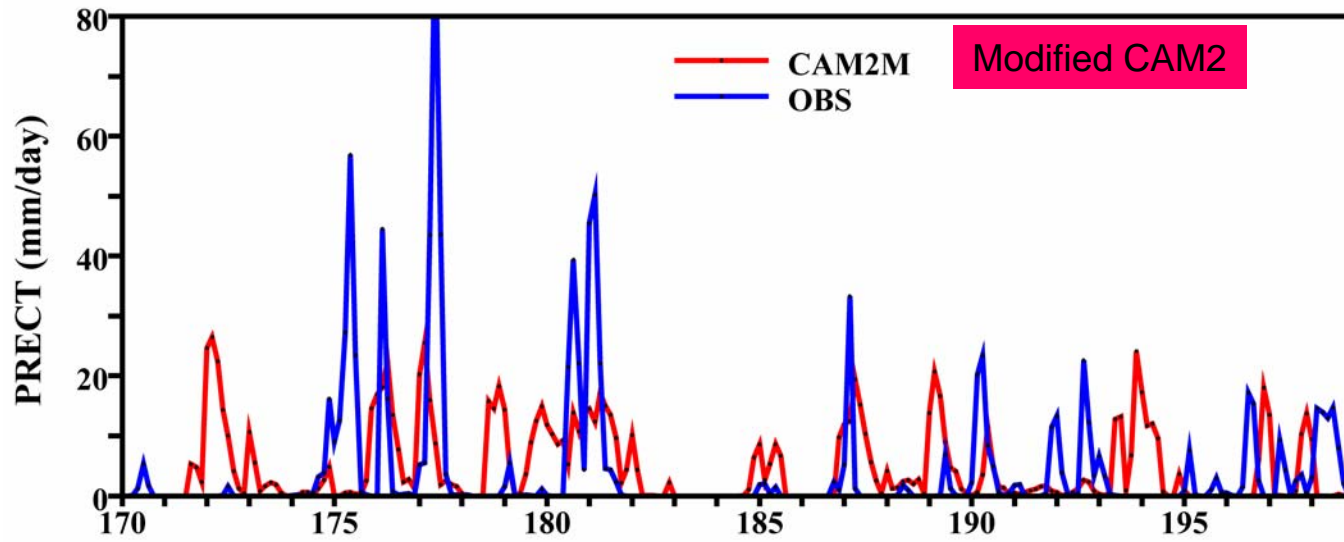
## Convective parameterization change in CAM2

- The CAM2 atmospheric humidity error manifests itself in other ways:
  - more frequent rain-out of moisture,  
but
  - with much lower intensity, than in ARM/SGP observations
- SCM studies indicate this model deficiency may be remedied by ***basing the convective trigger function on dynamical convective available potential energy (DCAPE)*** that accounts for effects of moisture advection (Xie and Zhang 2000 *J. Geophys. Res.*).
- Shaocheng Xie has recently implemented this new trigger function in the CAM2.

## Simulated and Observed Precipitation



ARM/SGP Site

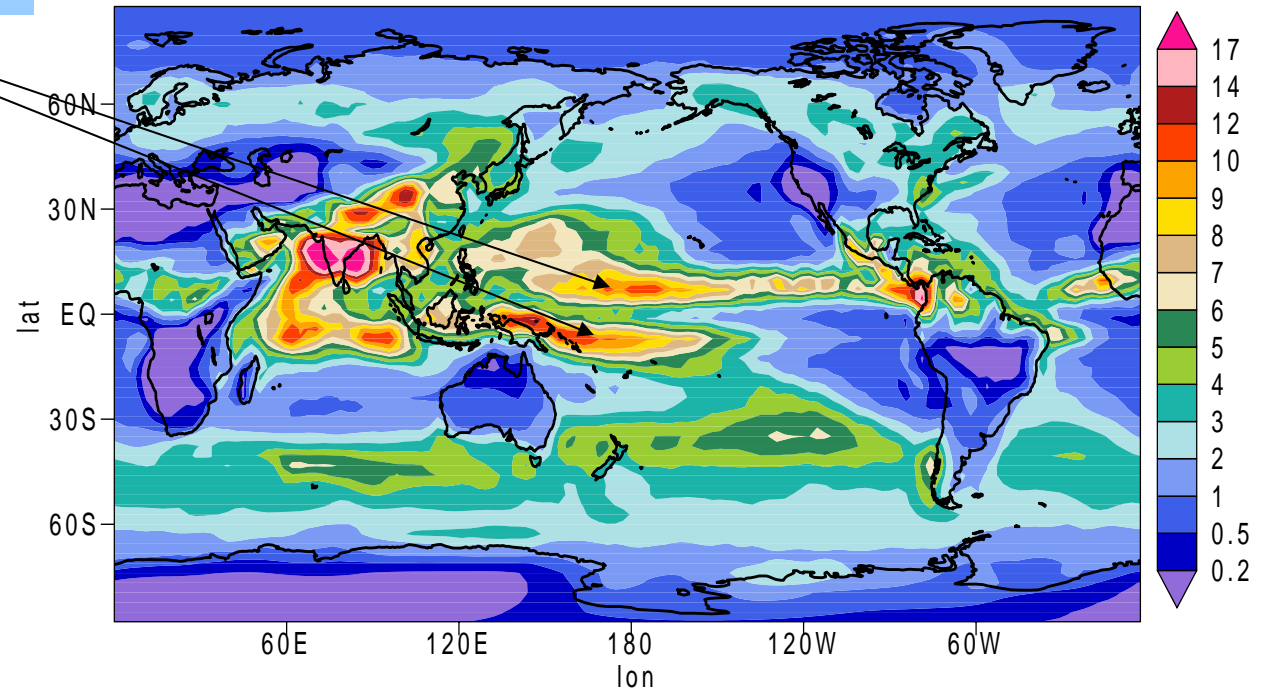


This change in the convective triggering function also improves the CAM2 large-scale climate simulation...

## Addressing CAM2 large-scale climate errors in CAPT:

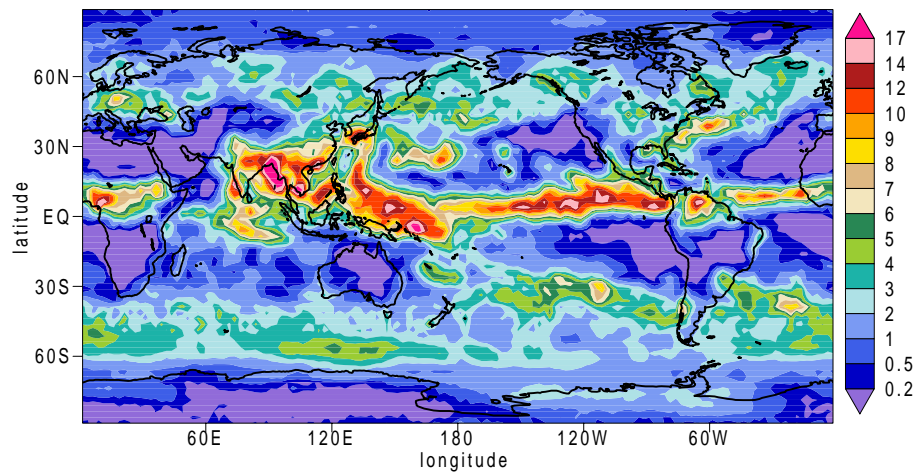
A problem endemic to CAM2 (and many other GCMs) is the presence of a spurious split ITCZ in the Western Tropical Pacific.

CAM2 Mean July Precipitation

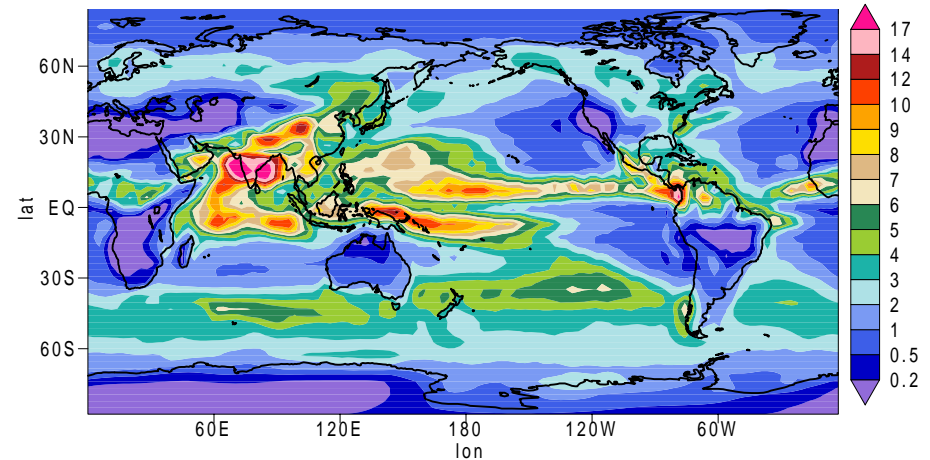


**S. Xie's modification of the CAM2 convective trigger also improves the climate simulation of the ITCZ in the Pacific**

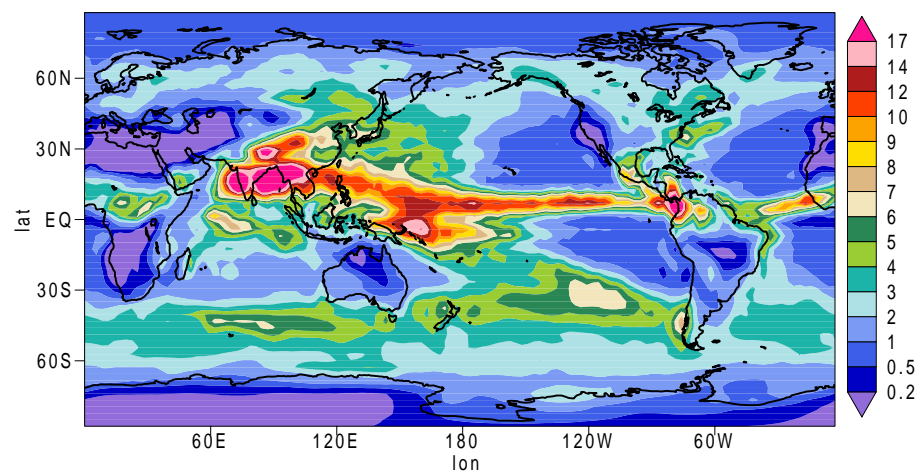
**July GPCP Precipitation**



**July Precipitation in Standard CAM2**



**July Precipitation in Modified CAM2**



# Future Plans

- Adapt approach for other ARM sites (e.g. Alaska, Tropical West Pacific) and other observational data sets (e.g. GEWEX/CEOP)
- Develop collaborations with other parameterization specialists
- Implement CAPT methodology in more models (e.g. GFDL's GCM)
- Refine testbed (initialization, model diagnostics, etc.) and related software tools
- Make the testbed available to the broader GCM community